Utah DOT Snow Removal Performance Metrics.....2.0

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First.....A Little About ME

- Grew up in Salt Lake City (Midvale) Utah
- Joined the US NAVY and went to boot camp 26 days after high school graduation to get $$$ for college
- **Sonar Technician 2nd class (E-5)** on naval destroyer USS Kinkaid (DD-965)
- Decomissioned ship in January 2003
- USS Kinkaid was sunk during a SINKEX in July 2004
- Now an artificial reef off the coast of Hawaii

First.....A Little About ME

- Sonar Technician 2nd Class on naval destroyer USS Fletcher (DD-992) after participating in the Sea Swap Program
- Goal of Sea Swap Program was to extend time "in theater"
- USS Fletcher was sunk during a SINKEX in July 2008
- Now an artificial reef off coast of Hawaii

****

- Spent **6 years** in the US NAVY – Received **Honorable Discharge**

First.....A Little About ME

- Attended Arizona State University (ASU) using the GI Bill after my 6-year enlistment in the US Navy
- Graduated in spring of 2009 with a **Bachelor of Science (BSE)** in Civil Engineering

ASU ARIZONA STATE UNIVERSITY

First.....A Little About ME

UDOT Keeping Utah Moving

- Started working for UDOT in fall of 2009 as an Unbenefited Intern in the Asphalt Mix Laboratory at UDOT Central where we did Material testing (asphalt, binder, aggregate, concrete)
- Got accepted into UDOT's Rotational Engineering Program in spring of 2011 – spent 3 years as a **Rotational Engineer**
- Earned my **Professional Engineering (P.E.) License** spring of 2014

First.....A Little About ME

- During time in Rotational Engineering Program at UDOT I got the opportunity to work in these 4 Departments:
  - Construction (6 mos)
  - Maintenance (6 mos)
  - Construction again (6 mos)
  - Design (12 mos)
  - Traffic & Safety (6 mos)

UDOT Keeping Utah Moving

- After getting a full time job at UDOT in spring 2014 I have worked:
  - Design (3 yrs)
  - Traffic and Safety (1 yr)
  - Currently in MAINTENANCE PLANNING (8 mos)

Now, Down To Business.....

Winter Road Weather Index

- UDOT rolled out what was called the **Winter Road Weather Index (WRWI)** in October of 2013 – 1st iteration of what would eventually become.....
- The **Snow & Ice Performance Measure** followed in October of 2015 – system has now been online for **just under 3 years** and for **3 winters**:
  - 2015/2016
  - 2016/2017
  - 2017/2018

Now, Down To Business.....

Winter Road Weather Index

- The **WRWI** and **Snow & Ice Performance Measure** were created in conjunction with UDOT Traffic Operation Center (TOC) Weather Group's
- **Jeff Williams (Weather Program Manager)**

  and.....
- **Cody Opperman (Weather Program Specialist)**
- UDOT's Weather Website:

http://www.udottraffic.utah.gov/ForecastView/Default.aspx

Initial Hesitation With GPS Units

- Transportation Technicians were at first very hesitant to have "tracking devices" installed in their plows
- Snow & Ice Performance Measure is supplemented by a GPS system installed in the plow trucks
- GPS units allow for Automatic Vehicle Location (AVL)
- **BIG BROTHER** is watching us....

Initial Hesitation With GPS Units

- GPS units work with **Force America controllers** inside of snow plows to document the locations of such parameters as:
  - Types of material dispensed (salt, brine, sand, etc.)
  - Rate of materials dispensed
  - Blade time up/down
  - Lane miles plowed
  - Vehicle min/max speed
  - Salt "blast" duration for emergencies and accidents
  - Pre-wetting time for anti-icing operations

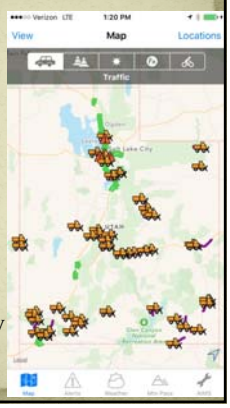
Initial Hesitation With GPS Units

- Decision came down Maintenance Planning and upper management's desire to better optimize snow plow operations → **be good stewards of TAXPAYER $$$**
- Case was made to the Transportation Techs by upper management that MILLION+ DOLLAR MACHINES, aka **Snow Plows**, are worth tracking despite the perceived **BIG BROTHER EFFECT** they were feeling
- Distrust with the new tracking system faded over time because.....

Time Heals All Wounds

Automatic Vehicle Location (AVL) System

- One thing that GPS units in snow plows allowed for is development of the Automatic Vehicle Location (AVL) system
- Using UDOT's Traffic app citizens can see the approximate locations of snow plows
- We set a 10 minute lag to keep plow drivers safe from The Unruly



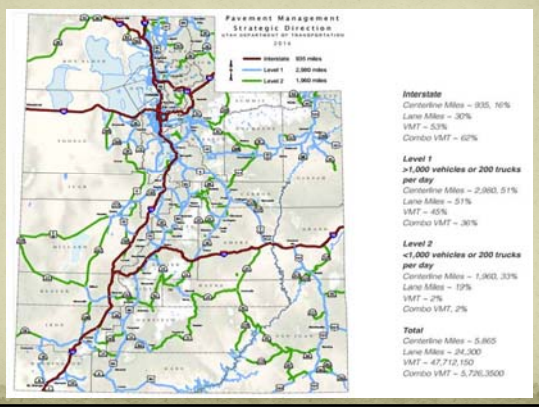
Automatic Vehicle Location (AVL) System

- **Beneficial for The Public:**
  - Can avoid where the snowplows are currently working
  - Can see what areas have already been plowed and are clear of snow and ice
  - Can see their tax **$$$'s** hard at work
- **Beneficial for UDOT:**
  - Better track plow movements to see what areas have already been plowed → **Reallocate Resources**
  - Respond to **Citizen Inquiries** to verify if plow has already been through and when they came through
  - **Plow Route Optimization** through trial and error

Some FACTS About Utah's ROADWAYS

- 5,865 Centerline Miles
- 24,300 Lane Miles
- 1,867 Bridges
- 25-35 Average Storm Events per year statewide
- Remove 65 million tons of snow & ice per year
- 500 Snow Plows
  - $5.6 million in Labor $$$ per year
  - $4.6 million in Equipment $$$ per year
  - $5.0 million in Material $$$ per year

Some FACTS About Utah's ROADWAYS



Some FACTS About Utah's SNOWFALL

- 80% of Utah's population is living along the Wasatch Front (Ogden, Salt Lake City, Provo)
- Terrain varies from **2000 ft - 13,500 ft** above sea level
- **Lake Effect Snowfall** – Great Salt Lake never freezes (salinity 5-27%) and causes its own weather formations
- Varied snowfall throughout Utah
  - Alta Ski Resort – 508 inches (42.3 ft) per year, record is 910 inches (75.8 ft) back in 1983
  - Wasatch Front – 40-120 inches per year (3.3 ft - 10 ft)
  - St. George – 3 inches per year
  - Wendover – 5 inches per year

Some FACTS About Utah's ECONOMY

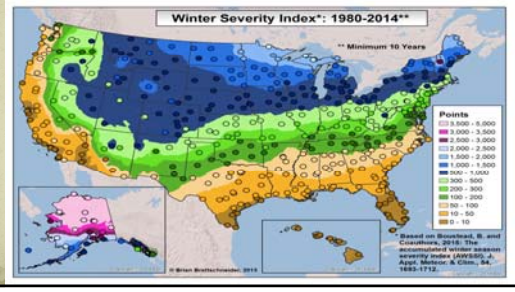
- **Economic Impact of a Single 24-Hour Storm Event:**
  - Wages & Salaries.....$42.81 M
  - Retail Sales.....$18.26 M
  - Federal Taxes.....$3.32 M
  - State & Local Taxes.....$1.98 M

- Total Economic Impact **$66.37 million LOST**

Source: American Highway Users Alliance performed by IHS Global Insight (2009)

Nationwide Index or Measures?

- **The Climate Network** (National Weather Service)
  - No **road weather data** is used
  - Snowfall is measured on **grass** – this methodology doesn't fit our needs in the transportation industry



Utah's Needs In A Measure/Index

- At UDOT we found that we needed a ***Real-Time Index*** to evaluate weather, road conditions, and the snow removal efforts performance by Maintenance Crews
- We have found that **snowfall rates & road temps** have the highest impacts on "roadway health"
- Our ***Real-Time Index*** accounts for blowing snow (snow drifts), freezing rain, & wet/dry snowfall

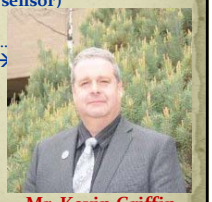
Using RWIS Sites To Gather Data

- With no nationwide method we began to look at our RWIS stations for data to parse
- **RWIS:** Roadway Weather Information System
- We use RWIS data along with a sophisticated algorithm to "GRADE" snow removal efforts
- Algorithm was developed by the UDOT Weather Group (namely **Jeff Williams & Cody Oppermann)**
- RWIS stations are spread out far apart throughout the state = Not a complete picture of ROADWAY HEALTH

RWIS Stations Along Wasatch Front

Data That RWIS Provides UDOT

- RWIS stations provide us with the following data:
  - Air Temp
  - Road Temp
  - Soil Temp
  - Soil Moisture
  - Wet-Bulb Temp
  - Snowfall Rate **(found through Visibility sensor)**
  - **Road Grip/Condition**
  - (see the "**Decision Matrix**" aka……
  - ……the **Griffin Grip Cube**) →
  - Dew Point
  - Wind Gust
  - Wind Speed
  - Wind Direction
  - Solar Radiance



Mr. Kevin Griffin

Using RWIS Sites To Gather Data

- UDOT owns **109+** RWIS stations total
- **69** of these RWIS stations are compatible with Snow & Ice Performance Measure
- The other **40** stations are mobile trailers or are older stations not compatible
- **Goal:** minimum of **1** RWIS site per Maintenance Station
- Expand by **1** RWIS station per month on average

RWIS Road Condition Sensors

- Road Condition Sensor is pointed at a 45° angle to maximize data accuracy (***usually*** the far right lane)
- Analyzes approximately **5 ft²** of pavement
- Full RWIS station with Contractor install and instrumentation:

≈ $45,000 - $50,000

Looking Toward the Future With.....
Connected/Autonomous Vehicles

- It is fiscally impractical to put RWIS stations along every section of corridor
- RWIS stations do not overlap; i.e. there are "gaps" that are not covered and thus → **do not** provide a clear picture of roadway weather or health
- Our goal is to have a statewide network for **Snow & Ice Performance Measure**
- UDOT has put forth a research proposal at **UTRAC (Utah Research Advisory Council)** to see if using Connected/Autonomous Vehicles help fill in "gaps"

Looking Toward the Future With.....
Connected/Autonomous Vehicles

Storm Intensity Index - SII

- Quantifies ***atmospheric conditions*** & ***road temperature*** into a single value = **Storm Intensity Index (SII)**
- **Storm Intensity Index (SII):** "The severity of the weather impacting the road. A value of **SII = 1** corresponds to **1"** of snowfall per hour with a road temp & wet bulb temp of **32° F** with light winds."
- **Storm Intensity Index (SII)** accounts for:
  1 - **Snowfall Rate** (found through Visibility sensor)
  2 - **Wind Gust** (≥ 20mph)
  3 - **Wet-Bulb Temperature** (used for determination of the ***Precipitation Type*** and ***Dry/Wet Snow***)
  4 – **Road Temperature**

Storm Intensity Index - SII

At temps > 35° F and dry road the SII will always equal 0

- **When road temperature < 35° F and road is not dry....**

1 - *Snowfall Rate*

- Visibility is used to estimate Snowfall Rate
- Precipitation occurrence is used to differentiate Fog from Snow

2 - *Wind Gust (≥ 20mph)*

- More impact with lower wet bulb temps (drier snow blows across road)
- Tends to cause snow drifting across roadways

Storm Intensity Index - SII

- **When road temperature < 35° F and road is not dry....**

3 - *Wet Bulb Temperature*

- Used instead of Air Temperature because it tells us more
- Major factor in if it **Rains** or **Snows**
- Used to distinguish **Rain** from **Snow** in the algorithm
- Low wet bulb temp equates to drier snow = easier to haul off
- Major factor in if precipitation evaporates or ices over

4 - *Road Temperature*

- The colder the road, the more difficult to mitigate
- Major factor in if precipitation evaporates or ices over

Snow & Ice Performance Measure

- The Snow and Ice Performance Measure then compares the 4 variables of the **Storm Intensity Index (SII)** to either the:
  - **Road Condition** (Dry, wet, slushy, snow, ice)
    - Different sensor than Road Grip

OR.....

  - **Road Grip** (A value between 0 and 0.82)
    - Different sensor than Road Condition

Snow & Ice Performance Measure

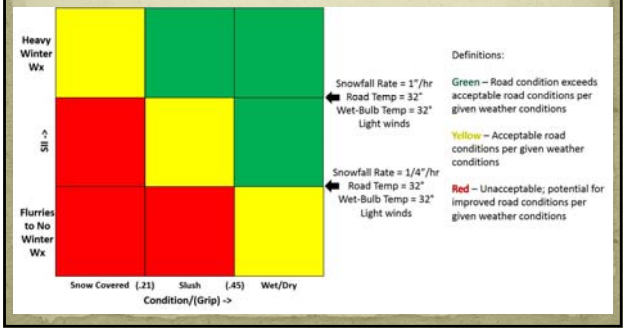
- UDOT uses the **CAUSE** **vs.** **EFFECT** approach
  - Atmospheric Conditions & Road Temperature **(CAUSE)**

VS.....

  - The resulting Road Grip or Road Conditions **(EFFECT)**
- **Road Grip/Conditions** categorized into:
  - Snow covered
  - Partially snow covered/slushy
  - Wet/dry

Decision Matrix

- Let us take a gander at the **Decision Matrix**..... aka **Griffin Grip Cube**



Decision Matrix Explained

Status of Snowfall	Snowfall Rate	Expected Mitigated Road Condition
Heavy	> 1" per hour	Snow Covered
Light to Moderate	0.25 to 1" per hour	Slushy/Partially Snow Covered
Flurries or No Snow	< 0.25" per hour	Wet or Dry

UDOT's Benchmark For Snow Removal

- UDOT's benchmark target for snow removal is to handle:

1" of snow / hour at 32° F

- The breakdown based on temperature:
  - **1"** per hour for **32° F** road temp & wet bulb temp
  - **3/4"** per hour for **22° F** road temp & wet bulb temp
  - **1/2"** per hour for **17° F** road temp & wet bulb temp

Storm Severity Index - SSI

- Storm Severity Index (SSI): The **Average SII** multiplied by the **Storm Duration** in HOURS.

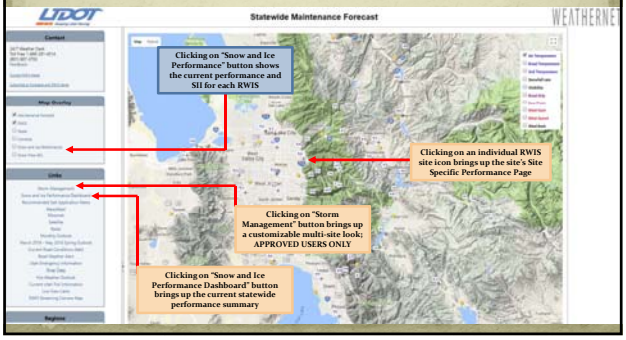
Storm Severity Index =
(**S**torm **I**ntensity **I**ndex) x (Duration of Storm)

→

SSI = (SII) x (Duration of Storm)

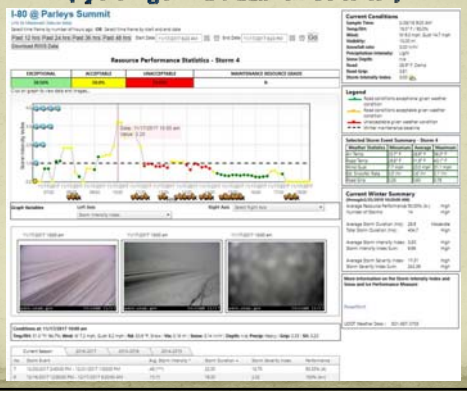
Let's See This Thing Already.....
RWIS/Forecast Page – Your Portal

- URL: **http://www.udottraffic.utah.gov/ForecastView/Default.aspx**



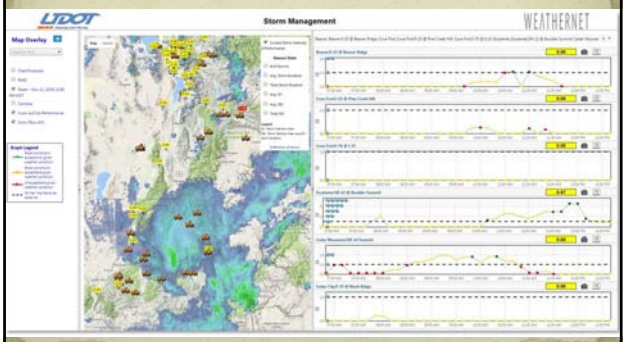
Site Specific Performance Page

(By clicking on individual RWIS site icon)



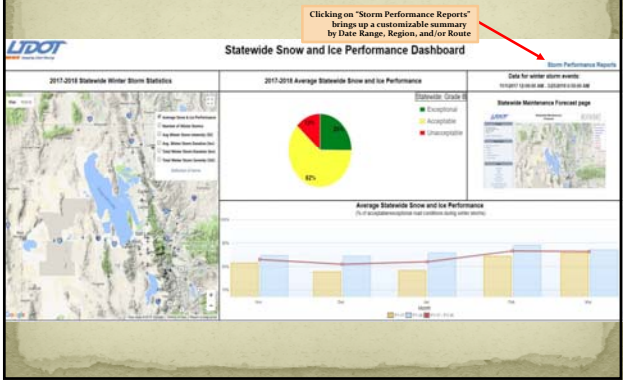
Storm Management Dashboard

(By clicking on "Storm Management" button, Authorized Users only)



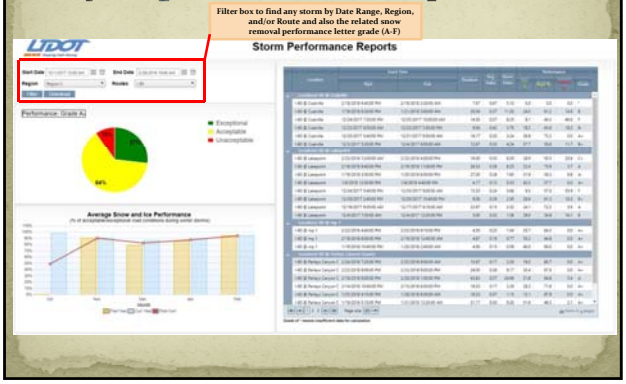
Statewide Snow & Ice Performance Dashboard

(By clicking on "Snow & Ice Performance Dashboard" button)



Storm Performance Reports

(By clicking on "Storm Performance Reports" button)



Challenges With This System

- Data Quality and Verification
  - RWIS Coordinator/Meteorologist manually checks data weekly with aid of saved camera images from RWIS stations
- Common Issues
  - Occasional road sensor inaccuracy
  - Sensor failure
  - Flurries in fog confuse sensors
  - High traffic prevents sensors from seeing roadway
  - Reasonable SII in extreme conditions
- Physical Challenges
  - Requires intensive RWIS Station maintenance (need them working!!)
  - Only samples a small area of roadway despite many lane-miles of responsibility

Future Improvements To Be Made

- The ever-expansion of our RWIS network
- Better storm identification
- Algorithm tweaks
- Instrumentation in market improves over time
- Set performance benchmarks for different priority routes
- Using Connected/Autonomous Vehicles to fill in "RWIS gaps"

Now.....Something Near and Dear To Me

- End of discussion about **Snow & Ice Performance Measure** and on to.....

Light Sabers!!

Challenges UDOT Plow Drivers Face

- **Plow Driver Hours** are long and unforgiving
- **Older Fleet** is slow to be replaced by new equipment
- **Filling All Vacancies** can be a problem – high turnover rate due to the dangers of the job and pay **$$$**
- **Bad Winter Driving Habits** of citizens can cause accidents

Challenges UDOT Plow Drivers Face

- **US-6 in Spanish Fork Canyon January 12th, 2017.....**

Challenges UDOT Plow Drivers Face

Spanish Fork Canyon --- January 12th, 2017

- **Terry Jacobson**, a 23 year veteran UDOT Transportation Technician in Region 3, was plowing WB lanes of SR-6 in Spanish Fork Canyon
- An impatient semi-truck driver pushed his UDOT plow off of the road while attempting to pass him on the right - clipped his Wing Plow
- Terry's snow plow gated through the W-beam guardrail and rolled down a 300 foot embankment

Challenges UDOT Plow Drivers Face

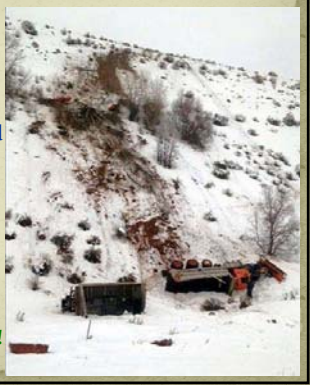
- Let us watch the **VIDEO** captured by the dash camera of a semi-truck driver heading in the opposite direction.....

https://youtu.be/HHXkafQ5pAU

Challenges UDOT Plow Drivers Face

- Terry survived the accident, but does not plow anymore
- Passenger side of cab was crushed. Would have killed a passenger had there been one
- Lends credence to why we constantly communicate to the public.....

STAY BEHIND THE PLOWS!



Challenges UDOT Plow Drivers Face

- UDOT Wing Plows used to have just an **orange flashing light** on the end of the wing
- In response to Terry's accident UDOT adopted what we call **"Light Sabers"** to go on the end of Wing Plows
- Let us watch a video of the **Light Saber** in action.....

https://youtu.be/5AxWknqruYM

THE END!!!

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